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# Energy Efficient, Data Centric Routing Algorithm In Mobile Wireless Sensor Nodes (Energy Savings Quantification)

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***Abstract-*** In this paper, we quantitatively (mathematically) reason the energy savings achieved in a wireless sensor grid network, by using circular leveling and sectoring routing algorithm. Due to the energy constraints on the sensor nodes (in terms of transmission and reception of energy) energy awareness has become crucial in sensor network. We provide analytical expression for the energy wastage that occurs when traditional Data Centric routing algorithm such as Direct Diffusion is utilized. Analytical results are validated through simulation, in NS2 simulator which shows the promising potentials of our leveling and sectoring technique.

***Keywords:*** Wireless Sensor Networks, Routing, Energy Efficiency, Gauss's Lattice Point.

## I. INTRODUCTION

Wireless Sensor Network (WSN) is comprised of small and low-cost sensors deployed in a particular region in order to monitor phenomena. A Wireless sensor Network consists of a large number of tiny, low power, cheap sensor nodes have sensing, data processing, and limited computing capabilities. As sensor nodes usually operate in unattended, harsh environment they are prone to failure and may run out of the battery power. An approach to conserve nodes energy is to use efficient routing protocol. The energy consumption can be managed efficiently by avoiding unnecessary transmission and reception of packets. In the proposed system we address various issues such as topology of network, flooding and redundancy management. The deployment of sensor nodes is either controlled (topology of sensor field is under the control of user) or random. In this paper we consider both the case of controlled deployment and random deployment of sensor nodes. In controlled deployment specifically the sensors are placed at the grid points of a uniform rectangular grid. The sensors placed at grid points are constrained with respect to resources such as memory, battery life etc. A sensor node consists of three basic elements namely processing unit, transceiver unit and power unit which is powered by an embedded battery. The transceiver unit is considered to be one of the most important units in terms of utilization of energy efficiently, thus care has to be taken in designing of the protocol so that it does not waste energy in unnecessary transmissions and receptions. The rapid development of sensor networks has proposed challenges in routing protocols and efficient use of energy resources. Therefore the need is felt to minimize the energy utilization by sensor nodes. The quantification of energy wastage from sensors (placed on a uniform rectangular grid) is done by using the result of Gauss on counting lattice points (in 2-dimensions) enclosed in a circle [1]. In this research paper we consider the paradigm where sensors are all stationary and Base station is mobile. We propose a data centric routing, fusion, and localization algorithm [2]. We quantify the energy saving achieved by our proposed algorithm.

This research paper is staged into V Sections. In section II, Related Literature is discussed. In section III, Data Centric routing is discussed using gauss lattice point problem. In Section IV Data centric routing energy efficient collect cost is discussed. In Section V Experimental results and Section VI Conclusions

## II. RELATED WORK

Some routing schemes assume that the sensor nodes can directly communicate with the sink node. We presented a comprehensive survey of routing techniques in wireless sensor networks.

They have the common objective of trying to extend the lifetime of the sensor network, while not compromising data delivery. There are numerous papers on using routing protocols to make wireless sensor networks stable, effective and power saving. Introduce the concept of using routing protocols in wireless networks. Recently, there are four leading ways of routing protocols. They are Data Centric flat protocols, hierarchical protocols, geographical protocols and Qos based protocols. Our paper will focus on Data Centric flat routing protocols. In Data Centric based negotiation routing in WSNs is to suppress duplicate information and prevent redundant data from being sent to the next sensor or the base station by conducting a series of negotiation messages before the real data transmission begins [3].

Negotiation-based routing in WSNs is used to suppress duplicate information and prevent redundant data from being sent to the next sensor or the base station by conducting a series of negotiation messages before the real data transmission begins.

Negotiation-Based Routing Protocols: These protocols use high-level data descriptors in order to eliminate redundant data transmissions through negotiation. Communication decisions are also made based on the resources available to them.

SPIN is a data-centric protocol that avoids passing redundant data and saves energy by performing negotiations among the nodes. To achieve this, SPIN protocol names the data (meta-data), and distributes the meta-data in the network through advertising.

However, nodes advertise the data to only interested neighbors. In SPIN, there is no specific format for meta-data definition as it varies from application to application. The flooding will disseminate data will produce implosion and overlap between the sent data, so nodes will receive duplicate copies of the same data [4].

This operation consumes more energy and processing by sending the same data to different sensors. The SPIN protocols are designed to disseminate the data of one sensor to all other sensors, assuming these sensors are potential BS. Hence, the main idea of negotiation-based routing in WSNs is to suppress duplicate information and prevent redundant data from being sent to the next sensor or the BS by conducting a series of negotiation messages before the real data transmission begins.

WSNs require low footprint communication schemes, which utilize minimum resources without compromising the required quality of service. Moreover, due to limited energy of the sensor nodes, the energy efficiency is one of the most important design considerations of the WSN routing protocols [5].

Due to limited resources of sensor nodes, important design goals for WSNs comprise: (a) minimizing the total energy consumption within the network (b) minimizing the overhead of control messages, (c) achieving fault-tolerance, and (d) balancing energy dissipation among the sensor nodes to avoid disconnected networks [6].

We find that different protocols perform well under different scenarios, and investigate the causes of the observed performance. Furthermore, we present a generic architecture of leveling and sectoring and experimental evaluation of routing protocols on the ns2 platform, and compare the performance of protocol with data centric routing protocol like direct diffusion. The results confirm the findings of our simulation study.

## III. Data centric routing: Energy Efficient Broadcasting

The data-centric routing communication in sensor networks is done by using various routing protocols such as Directed Diffusion or spin. These systems implement data centric routing "interests" or "queries" are routed to nodes that might contain matching data, and responses are routed back to the querying nodes. Because data-centricity abstracts the identity of nodes producing the data, such systems usually require flooding the interest or query (either globally or scoped geographically) to discover nodes that contain matching data [7]. These systems are appropriate for long-lived queries initiated by users from outside the network. Examples of such queries include tracking an object, or continuously computing aggregates over a sensor field. Sensor networks will need support for more flexible and efficient ways of accessing the data, however, than that provided by data-centric routing systems. An obvious requirement is that of a "one-shot" query: that which computes, say, the maximum temperature observed in a sensor field in the last 5 minutes. Implementing such queries using data-centric routing may be inefficient, for two reasons: the cost of flooding may dominate the overall cost of the query in large networks; in smaller networks, such queries will be frequently issued from within the network (for example, by individual nodes that perform some action based on the results of the query such as turning on a camera) and the cost of flooding each query from internal nodes will adversely impact the lifetime of the overall system. The above drawback of the data centric routing can be overcome by using proposed leveling and sectoring algorithm.

### 3.1 Efficient broadcasting

The sink is interested in broadcasting the request to all the nodes in the sensor Field. It will broadcast the request to the nodes within its transmission range and it will be forwarded by its neighboring nodes to all the nodes within the sensor field. For example the sink broadcast a request to know within the sensor field where the temperature is higher than 70 ◦F. Consequently, the nodes with sensor readings matching this request are addressed. Note that data-centric routing provides routes according to the query content and, hence, the nodes that send information change for each query. Moreover, using a single data-centric query, multiple nodes in distant locations can be addressed [8].

 

**3.2 Explanation of data centric routing**

[5] Data-centric routing refers to the type of query message initiated through the sink. Instead of node IDs, data-centric routing requires attribute-based naming. For attribute-based naming, users are more interested in querying an attribute of the phenomenon, rather than querying an individual node. Some of the protocols that may apply data-centric principles are flooding, gossiping, SPIN, directed diffusion, energy-aware routing protocol, rumor routing, gradient-based routing, CADR, COUGAR, ACQUIRE, Shortest Path Minded SPIN (SPMS) and solar-aware routing.

**3.3 Leveling and sectoring**

We consider a rectangular grid as the sensor field for planned deployment. The sensors are placed at the intersection of grid lines. The intersection points are called lattice points. For simplicity, the grid lines are one unit apart from each other both horizontally and vertically. Thus, in grid based sensor field the sensor no desire at lattice points, one unit apart from each other vertically and horizontally. The points obtained by inter section of grid lines are called lattice points. Traditionally, in a wireless network with Omni directional antennas, flooding algorithm is utilized for routing packets. Such an algorithm wastes the resources such as energy and further leads to congestion on the channel. To improve the performance (and alleviate associated problems), controlled flooding/gossip is utilized for probabilistic flooding. Such routing algorithms are designed to propagate packets from any source to any destination. But in certain networks such as wireless sensor networks with sensors as well as BS being static, the packets must be propagated from sensors to the base station. Thus, it is very natural to design, directed flooding based routing algorithms. Several researchers proposed interesting variations of directed flooding [9]. did energy efficient routing in mobile cognitive wireless sensor networks. The problem of key distribution in dense WSN using leveling and sectoring was solved by [10]. Power aware clustering algorithm for WSN [11]. Fusion and localization algorithm using leveling and sectoring was performed by [12]. Our research group proposed leveling and sectoring for routing in static wireless sensor networks. Detailed description of the algorithm is provided below.

**3.4 Signal Strength based Leveling and Sectoring**

The purpose of this algorithm is to divide the grid into levels and sectors based on signal strength received from the BS.

Leveling: The BS is located at the center of the grid. It sends signal with a certain power level and all those sensor node that receive this signal will set their level id to one. Then the BS will increase its power level and transmit the signal. This time those nodes which receive the signal for the first time set their level id to two. This procedure continues until all the nodes in the network have their level id's determined.

Sectoring: Using the directional antenna, the BS will send signals with maximum power and divide the sensor field into equiangular sectors with an angle of theta (Let theta be 45). After receiving sector id every sensor node in the network has node id, level id, sector id as identifiers.

**3.5 Hop count based Leveling and Sectoring**

The purpose of this algorithm is to divide the grid into levels and sectors based on hop count value sent in the packet by the BS.

Leveling: The BS is located at the center of the grid. The BS sends a packet to its neighboring node which are in its transmission range and those are considered at level one (as the packet reaches to them in one hop). The nodes which had received the packet will forward it to its neighboring node and the node that received this packet for the first time, will set their level id as two and this process continue until all the nodes in the network have their level id determined.

Sectoring: The BS has a directional antenna or it has the beam forming capability. Thus, it can transmit signal in a specific direction with certain angle and divide the sensor field into equiangular sectors. After receiving a sector id the sensor has node id, level id, sector id as identifiers.

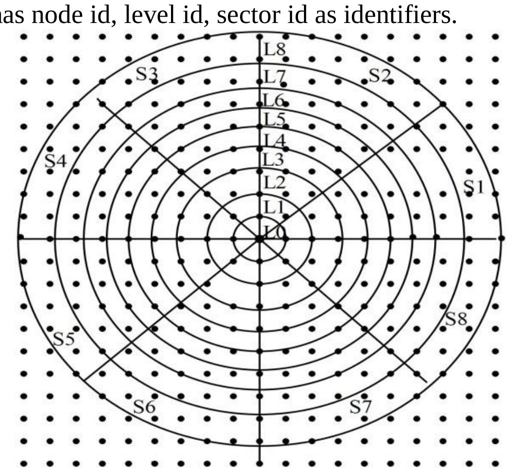


Figure 1: Leveled and sectored sensor grid field.

After having node id, level id, sector id as identifiers with all the sensors, the base station broadcasts a content based query containing data type, data operator, data threshold. Route reply node id, level id, sector id, data type, data value is done through with following criterion. An intermediate node is permitted to accept the packet only if the level id of the sender node is greater and sector id has a difference of utmost 1. Hence, the leveling and sectoring prevents the unnecessary transmission [13].

**Planned deployment quantification of energy saving in broadcasting**

The nodes should transmit the packet from the lower level to the higher level i.e. from BS to the Sensor node. If any node situated at higher level is transmitting the packet to lower level, then it is wasting energy. As shown in figure Let us consider a grid as shown in

 

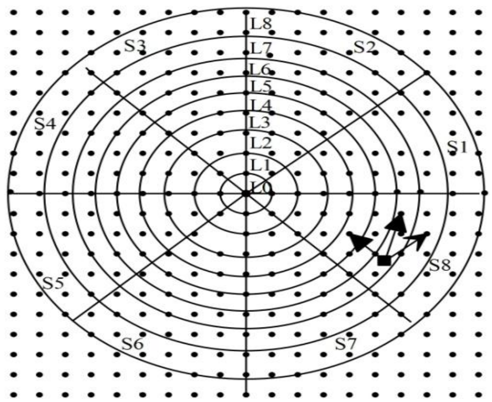


Figure 2: Energy Efficient collect cost

At every point in the grid (consider as a lattice point) a sensor is paced. The entire grid has been divided into levels such as L1, L2, … , L8 and further divided into sector as S1,S2, … ,S8.

The symbols used in next section are as following:

$X_T$ = total no of transmitting nodes

$X_R$ = total no of receiving nodes

$E_T$ = energy required for transmission

$E_R$ = energy required for reception

N = total no of nodes in the grid

$N_i$ = total no of nodes at i location

$N_C$ = total no of cluster heads in the grid

D = nodes between source node and BS

$D_C$ = cluster heads between source node and BS

M = total no of levels

**Random deployment Quantification of energy saving in broadcasting**

We provide analytical modeling of the energy wastage in the absence of Leveling and Sectoring protocol by considering the network in the form of binary tree, nested tree and Q-ary tree. Network topology plays an important role in the execution of network operations and the related power consumption. In order to realize the wastage, we first consider linear arrangement of nodes (being the simplest arrangement of nodes). In a linear arrangement, there are n sensor nodes placed in a line, with the first node functioning as the Base Station. Assuming the BS node to be broadcasting, mathematically

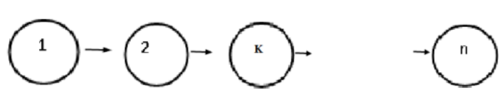


Figure 3: Linear Arrangement of WSN.

The nodes should transmit the packet from the lower level to the higher level i.e. from BS to the Sensor node. If any node situated at higher level is transmitting the packet to lower level, then it is wasting energy.

Number of nodes unnecessarily involved in transmission, Wasted Transmission Energy, where, Number of nodes unnecessarily involved in reception, Wasted Reception Energy. Let us consider a tree as shown in

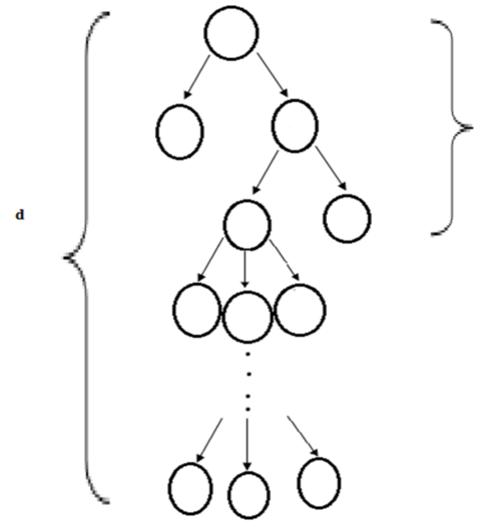


Figure 4: Random Deployment of WSN

**Analytical Modeling**

The total energy used in propagation of packet from base station to all nodes can be calculated as $= X_T E_T + X_R E_R$ Further, we can compute the total number of nodes for following cases:

**Planned Deployment Broadcasting**

Consider a rectangular grid with the following cases.

**Pure Flooding:**

In this condition no rules are applied for packet broadcast. The grid is deployed and the nodes are transmitting using broadcasting mechanism only.

With no forwarding rules in place, all the nodes will be involved in transmission and reception. In case of grid with cluster heads, we are assuming that cluster heads are the only nodes, capable of transmitting the information. All other nodes can receive but can't transmit, unless it is a source node. This assumption applies to all the cases.

If there are no cluster heads

$$X_T = N - 1 \quad (1)$$

$$X_R = N - 1 \quad (2)$$

If there are cluster heads

$$X_T = N_C - 1 \quad (3)$$

$$X_R = N - 1 \quad (4)$$

**Partially Controlled Flooding:**

In this condition, when a node receives a packet, it forwards the packet probabilistic ally. This situation is like getting a reward after tossing a coin. If head comes up, it will forward the packet otherwise the node will drop it. Hence there are upper and lower bounds, for total number of nodes involved in transmission and reception. Node count will be least, if there is a shortest path between source and the BS. Along with that all the nodes must forward the packet in that path. Hence the lower bound is the distance between the source and the BS. In worst case, all the nodes can transmit the packets. Hence, it defines the upper bound.

If there are no cluster heads

$$|D| \leq X_T \leq N-1 \quad (5)$$

$$|D| \leq X_R \leq N-1 \quad (6)$$

If there are cluster heads

$$|D| \leq X_T \leq N_C-1 \quad (7)$$

$$|D| \leq X_R \leq N-1 \quad (8)$$

**Flooding with leveling and sectoring:**

In this case strict forwarding rule with level and sector ids have been imposed in leveled and sectored sensor grid field. Hence, the packets originating from a lower level must be dropped by a higher level node. Similarly, apart from the neighboring sectors, packets coming from distant sectors must be dropped by a receiving node.

If there are no cluster heads

$$X_T = \sum_{i \varepsilon S} N_i - 1 \quad (9)$$

where S is the set of \{nodes in source sectoroid and below sectors, nodes in left sectoroid and below sectors, nodes in right sectoroid and below sectors\}

$$X_R = \sum_{i \varepsilon S} N_i - 1 \quad (10)$$

where S is the set of { nodes in source sectoroid and below sectors, nodes in left sectoroid and below sectors, nodes in right sectoroid and below sectors, nodes in left+1 sectoroid and below sectors, nodes in right+1 sectoroid and below sectors}

If there are cluster heads

$$X_T = \sum_{i \varepsilon S} N_i - 1 \quad (11)$$

where S is the set of Cluster heads in source sectoroid and below sectors, Cluster heads in left sectoroid and below sectors, Cluster heads in right sectoroid and below sectors

$$X_R = \sum_{i \varepsilon S} N_i - 1 \quad (12)$$

where S is the set of {Nodes in source sectoroid and below sectors, Nodes in left sectoroid and below sectors, Nodes in right sectoroid and below sectors, Nodes in left+1 sectoroid and below sectors, Nodes in right+1 sectoroid and below sectors}

**Random deployment Broadcasting**

We consider a sector in which there is a balanced binary tree of nodes.

**Energy Savings in Transmission**

$P_t$ = Energy spent in transmitting a packet.

When a query is broadcasted over sensor field, the number of packet transmitted are

Number of nodes at level 'j' = $2^j$

The number of nodes involved in rebroadcast= $E_t$

$$E_T = (1+2+2^2+\ldots+2^i-1) - (2^i-1)P_t$$

**Energy Savings in Reception**

$p_t$ = Energy spent in reception a packet.

It should be noted that when nodes at level 'i' transmit the packet, number of nodes unnecessarily involved in reception of packets and thus wasting energy in reception are

The number of nodes involved in reception is =$E_T$

$$E_T = (1+2+2^2+\ldots+2^i-1) - (2^i-1)P_r$$

we estimated $E_t$,$E_r$ with respect to nodes at level 'i'.

We thus combine the energy saved with respect to

I) Broadcasting query for data centric routing.

II) Collect Cost: sending data from nodes at level 'i' towards BS.

Now, we can estimate the total energy saved with leveling and sectoring algorithm with respect to a single sector.

$$E_T = (1+2+2^2+\ldots+2^i-1) - (2^i-1)P_t \quad (13)$$

$$E_T^G = \sum_{i=2}^{|M|} (2^i-1)p_t \quad (14)$$

$$E_T^G = \sum_{i=2}^{|M|} 2^i - (m-1)p_t \quad (15)$$

$$= [(2^{M+1}-2)-(M-1)]p_t \quad (16)$$

$$= [(2^{M+1})-(M-1)]p_t \quad (17)$$

$$E_T^G = \sum_{i=2}^{|M|} (2^{i-1}-1)p_t \quad (18)$$

$$= \sum_{i=3}^{|M|} (2^{i-1}-(m-2))p_t \quad (19)$$

$$= [(2^m-4)-(m-2)]p_t \quad (20)$$

$$= [2^m-m-2)]p_t \quad (21)$$

{$E_t$,$E_r$} are estimated with respect to energy savings in a sector. when these quantities are multiplied by number of sector. we get the effective energy saving.

## IV. DATA CENTRIC ROUTING: ENERGY EFFICIENT COLLECT COST

### 4.1 Planned deployment energy saving in Collect Cost

In grid based sensor field the sensor nodes are placed at lattice point with a unit distance apart from each other vertically and horizontally. By taking certain radius value the given grid is classified into a level. By changing the radius value sequentially we are classifying the various sensor nodes (placed at lattice point) into different levels.

To determine the no of lattice point in the level we will use gauss lattice point theorem [14]. It determines the no. of lattice points inside and on the boundary of the circle of radius r by using following expression

$$N_{(r)} = 1 + 4[r] + 4\sum_{i=1}^{[r]}\left[\sqrt{r^2+i^2}\right] \quad (22)$$

The number of sensor nodes in a specific level is calculated using

$$N_{Level_i} = N_{r_i} - N_{r_{i-1}} \quad (23)$$

Further the grid is divided into sectors with fixed angle. A sector along with a specific level is know as sectoroid. If there are S equally partitioned sectors, then total number of sensor nodes in a sector can be calculated using

$$N_{Sector} = 1 + \left[\frac{N_{(r)}}{S} - 1\right] \quad (24)$$

$$N_{sectoriod} = N_{Sector_i} - N_{Sector_{i-1}} \quad (25)$$

Now total number of sensor nodes in a sectoroid can be calculated as

The nodes should transmit the packet from the higher level to the lower level i.e. from sensor node to the BS. If any node situated at lower level is transmitting the packet to higher level, then it is wasting energy.

Let us consider a grid as shown in figure lattice_basic. At every point in the grid (consider as a lattice point) a sensor is paced. The entire grid has been divided into levels such as L1,L2, ..., L8 and further divided into sector as S1,S2,… ,S8.

**4.2 Random deployment energy saving in Collect Cost**

If we consider an arbitrary graph, a spanning tree can be extracted which is minimally a binary tree. Hence, we consider the case of balanced binary tree, nested tree and Q-ary tree for mathematically estimating the wastage of energy in transmission/reception. The consideration of simplest network topology would help in computation of energy wastage in absence of Leveling and Sectoring Protocol. The same can be applied to the real time WSNs.

The WSN is in the form of a Balanced Binary tree of depth d. The root node of the tree is the Base Station (BST). A node at depth ‘i’ broadcasts information which is being automatically received by the ‘i+1’ th depth and is transmitted further, since leveling and sectoring protocol is not used. As the nodes are arranged in the form of a binary tree nodes are involved in broadcasting. However, the transmission/reception to ‘i+1’th depth cannot be stopped. The nodes placed at further depths (depth greater than ‘i+1’) are involuntarily involved in transmission/reception (the transmission/reception to such nodes can be stopped through leveling and sectoring).

We provide analytical modeling of the energy wastage in the absence of Leveling and Sectoring protocol by considering the network in the form of binary tree, nested tree and Q-ary tree.

Network topology plays an important role in the execution of network operations and the related power consumption. In order to realize the wastage, we first consider linear arrangement of nodes (being the simplest arrangement of nodes). In a linear arrangement, there are ‘n’ sensor nodes placed in a line, with the first node functioning as the Base Station. Assuming the ‘k^th^’ node to be broadcasting, mathematically Fig. 3 show Linear Arrangement of Wireless Sensor Nodes Number of nodes unnecessarily involved in transmission, Wasted Transmission Energy, where, Number of nodes unnecessarily involved in reception, Wasted Reception Energy. Formula

Number of nodes unnecessarily involved in transmission,

$$B_k = n - k - 1 \quad (26)$$

- Wasted Transmission Energy,

$$B_k = n - k - 1 \quad (27)$$

$$T_x = E_t + E_t(n - k - 1) \quad (28)$$

- Where, $E_t$ - Transmission energy

Number of nodes unnecessarily involved in reception,

$$B_k = n - k \quad (29)$$

- Wasted Transmission Energy,

$$R_k = E_r(n - k - 1) \quad (30)$$

- Where, - $E_r$ Reception energy

Therefore,

- For, Pure Flooding:
- Transmission

Number of nodes unnecessarily involved in transmission,

$$B_{t_i} = \left[\sum_{j=i+2}^{[d]} 2^{j-i-1}\right] 2^i \quad (31)$$

- Wasted Transmission Energy,

$$T_x = E_t + E_t\left[B_{t_i}\right] \quad (32)$$

- Reception:

Number of nodes unnecessarily involved in Reception,

$$B_{t_i} = \left[\sum_{j=i+2}^{[d]} 2^{j-i}\right] 2^i \quad (33)$$

- Wasted Reception Energy,

$$R_x = E_r + E_r\left[B_{r_i}\right] \quad (34)$$

- For, Controlled Flooding:

In the case of controlled flooding each node which receives a packet, broadcasts the packet with probability 'p' independent of other nodes.

Expected number of nodes unnecessarily involved in transmission,

$$B_{t_i} = \left[\sum_{j=i+2}^{[d]} 2p^{j-i-1}\right] 2^i \quad (35)$$

Expected wasted Transmission Energy,

$$T_x = E_t + E_t\left[B_{t_i}\right] \quad (36)$$

- Reception:

Expected Number of nodes unnecessarily involved in Reception,

$$B_{r_i} = \left[\sum_{j=i+2}^{[d]} 2p^{j-i}\right] 2^i \quad (37)$$

Expected Wasted Reception Energy,

$$R_x = E_r + E_r[B_{r_i}] \qquad (38)$$

The wireless sensor network is in the form of a Q-ary tree of depth'd'. The following expressions are generalizations of those derived for binary tree.\\

- Pure Flooding
- Transmission

Number of nodes unnecessarily involved in transmission,

$$B_{t_i} = \left[\sum_{j=i+2}^{[d]} q^{j-i-1}\right] q^i \qquad (39)$$

- Wasted Transmission Energy

$$T_x = E_t + E_t[B_{t_i}] \qquad (40)$$

- Reception

Number of nodes unnecessarily involved in reception

$$B_{r_i} = \left[\sum_{j=i+2}^{[d]} q^{j-i}\right] q^i \qquad (41)$$

- Wasted Reception Energy,

$$R_x = E_r + E_r[B_{r_i}] \qquad (42)$$

- Controlled Flooding

In the case of controlled flooding, each node which receives a packet, broadcasts the packet with probability 'p' independent of other nodes.

- Transmission

Expected number of nodes unnecessarily involved in transmission,

$$B_{t_i} = \left[\sum_{j=i+2}^{[d]} qp^{j-i-1}\right] q^i \qquad (43)$$

Expected wasted Transmission Energy,

$$R_x = E_r + E_r[B_{r_i}] \qquad (44)$$

- Reception

Expected number of nodes unnecessarily involved in reception,

$$B_{r_i} = \left[\sum_{j=i+2}^{[d]} qp^{j-i}\right] q^i \qquad (45)$$

Expected wasted Reception Energy,

$$R_x = E_r + E_r[B_{r_i}] \qquad (46)$$

## V. SIMULATION AND RESULT ANALYSIS

The NS2 simulations shows the comparison between the existing data centric routing protocol such as direct diffusion with the proposed leveling and sectoring by considering the following performance metrics such as throughput, delay, packet delivery ratio, energy consumption.

The simulation performed (based on mathematical modeling) certain assumptions are made for grid and random deployment. Following are the assumptions made for simulations

1. Both sensor node and base station are static.
2. The leveling is done based upon hop count method (i.e. by using coordinate) and sectors are divided by assumption of angle 45 degree as shown in figure 1.

Table1. Performance of packet delivery ratio

| PDR(packet delivery ration) | | |
|---|---|---|
| ***Time*** | ***Existing*** | ***Proposed*** |
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |
| 4 | 0 | 0 |
| 5 | 0 | 0 |
| 6 | 0 | 0 |
| 7 | 0 | 0 |
| 8 | 2 | 0 |
| 9 | 4 | 0 |
| 10 | 9 | 9 |
| 11 | 14 | 16 |
| 12 | 19 | 29 |
| 13 | 24 | 55 |
| 14 | 29 | 81 |
| 15 | 32 | 94 |

Table 1 describes the performance of packet delivery ratio with direct diffusion approach and level sectoring algorithm approach. It shows level sectoring algorithm approach performs better performance than direct diffusion approach. Packet delivery ratio is nothing but ratio between packets received by destination to total packets generated by source. Packet delivery ratio is increased from time to time in level sectoring algorithm approach compare to direct diffusion approach.

Highest packet delivery ratio is measured at last with 94 in level sectoring algorithm approach. Lowest packet delivery ration is measured at last with 32 in direct diffusion approach. At the time of starting there is no PDR.

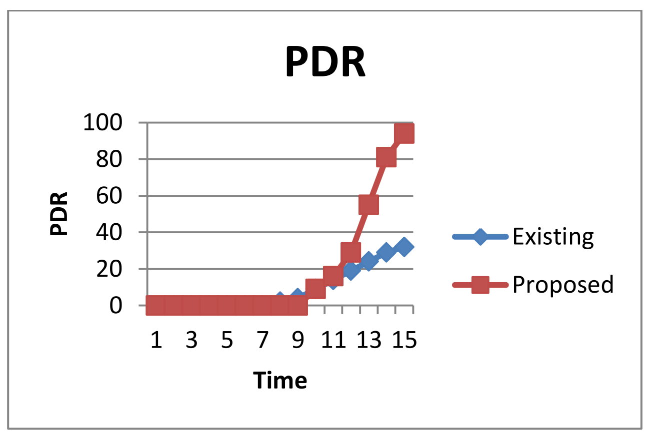


Figure5: graphical performance of PDR

Table 2:- performance of energy consumption

| Energy Consumption | | |
|---|---|---|
| ***nodes*** | ***proposed*** | ***Existing*** |
| 0 | 51.053331061756857 | 60.019953809687848 |
| 5 | 44.002402915620436 | 31.85138540894323 |
| 10 | 37.219373498679772 | 79.243654515242042 |

| | | |
|---|---|---|
| 15 | 38.844877569398321 | 76.72324272651376 |
| 20 | 41.905312729955327 | 41.961944355611671 |
| 25 | 78.784572504826158 | 57.418399796550347 |
| 30 | 99.004073929509175 | 53.543436691883691 |
| 35 | 59.131646132623608 | 62.073787237551898 |
| 40 | 95.934638830802697 | 97.403155033198729 |
| 45 | -7.3538708674506665 | 83.657105585400529 |
| 50 | 80.098610906907638 | 85.118877647965618 |

Table 2 shows the energy consumption at every node. It differentiates energy consumption performance in both direct diffusion approach and level sectoring algorithm approach. Energy consumption can be calculated as difference between current energy to initial energy. If energy level of node is 0 that is node haven't ability to receive or transfer packets highest energy consumption can be noted at 40 nodes with the value of 97.403155033198729 in direct diffusion approach. Lowest energy consumption can be noted at 57 nodes with the value of -7.3538708674506665.

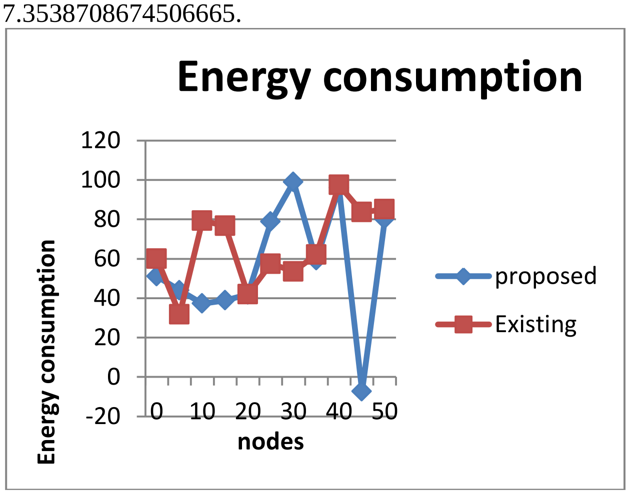


Figure6:- graphical representation of energy consumption

Table3:- performance of delay

| Delay(s) | | |
|---|---|---|
| ***Time*** | ***Existing*** | ***Proposed*** |
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |
| 4 | 0 | 0 |
| 5 | 0 | 0 |
| 6 | 0 | 0 |
| 7 | 0 | 0 |
| 8 | 0.42268403633686696 | 0 |
| 9 | 0.19896534948305214 | 0 |
| 10 | 0.10477200764986694 | 0.053161582841825802 |
| 11 | 0.075540005011981881 | 0.12217533638055189 |
| 12 | 0.061298465265319936 | 0.040328464464682003 |
| 13 | 0.052870860109132257 | 0.023310197462582581 |
| 14 | 0.04729884992114379 | 0.017119684762771408 |
| 15 | 0.045166002271054453 | 0.01538128939684064 |

The above table shows distinguished between direct diffusion approach and level sectoring algorithm approach in delay performance. Clearly the above table shows our level sectoring algorithm approach reduces the delay than direct diffusion approach.

Delay is the difference between the time at which packets generated by sender and time at which packets received by receiver. Highest delay can be measured at 8 minutes with delay 0.4226840363 in existing. Lowest delay can be measured at 15 minutes with delay 0.01538128939684064. At the time of starting there is no delay. From above table we clearly say that delay can be reduced by using level sectoring algorithm approach.

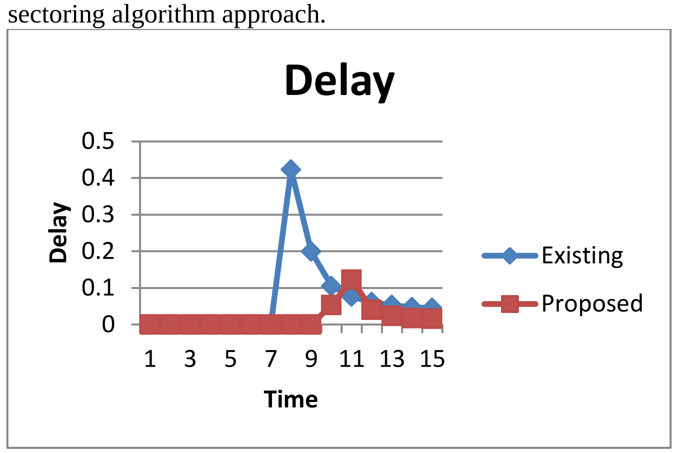


Figure 9:- graphical representation of delay

Table4:- performance of throughput

| Throughput | | |
|---|---|---|
| ***Time*** | ***Existing*** | ***Proposed*** |
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 3.2 | 28 |
| 4 | 4 | 40.4 |
| 5 | 4 | 45.6 |
| 6 | 4 | 40.4 |
| 7 | 4 | 35.6 |
| 8 | 4 | 47.6 |
| 9 | 4 | 38.4 |
| 10 | 4 | 38.8 |
| 11 | 4 | 27.6 |
| 12 | 4 | 47.2 |
| 13 | 4 | 39.2 |
| 14 | 4 | 41.2 |
| 15 | 4 | 38.4 |

The above table shows distinguished between direct diffusion approach and level sectoring algorithm approach in throughput performance. Clearly the above table shows our level sectoring algorithm approach performed well than direct diffusion approach. Throughput can be defined as number of bytes transferred in one unit time .Highest throughput can be measured at 15 minutes in proposed method. Lowest throughput can be measured at 8 minutes in direct diffusion approach. Finally we say that throughput is increased in level sectoring algorithm approach than direct diffusion approach.

The simulation result shows exponential saving of energy obtained when leveling and sectoring algorithm being used when compare to the existing data centric algorithm.

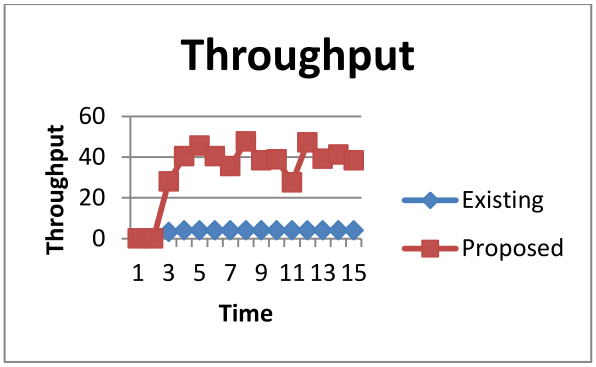


Figure10:- graphical representation of throughput

## VI. CONCLUSION

We have presented the mathematical formulation of energy savings in a planned and random deployment of sensor field which uses circular leveling and sectoring routing algorithm for planned deployment and tree structure for random deployment. The energy savings is in the form of number of transmitting and receiving of packets by nodes are compared with direct diffusion algorithms. In collect cost Each node sends the data to the neighboring node of smaller level id and sector id in a chain like system to compute a suitable a path till it reaches at the Base Station and in broadcast BS sends the data to the neighboring node of higher level id and sector id in a chain like structure until it reaches to all the nodes in the sensor field. Simulation result confirms that the proposed leveling and sectoring algorithm performs better than, direct diffusion and reduces energy consumption, packet delivery ratio, delay and increases through put.

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